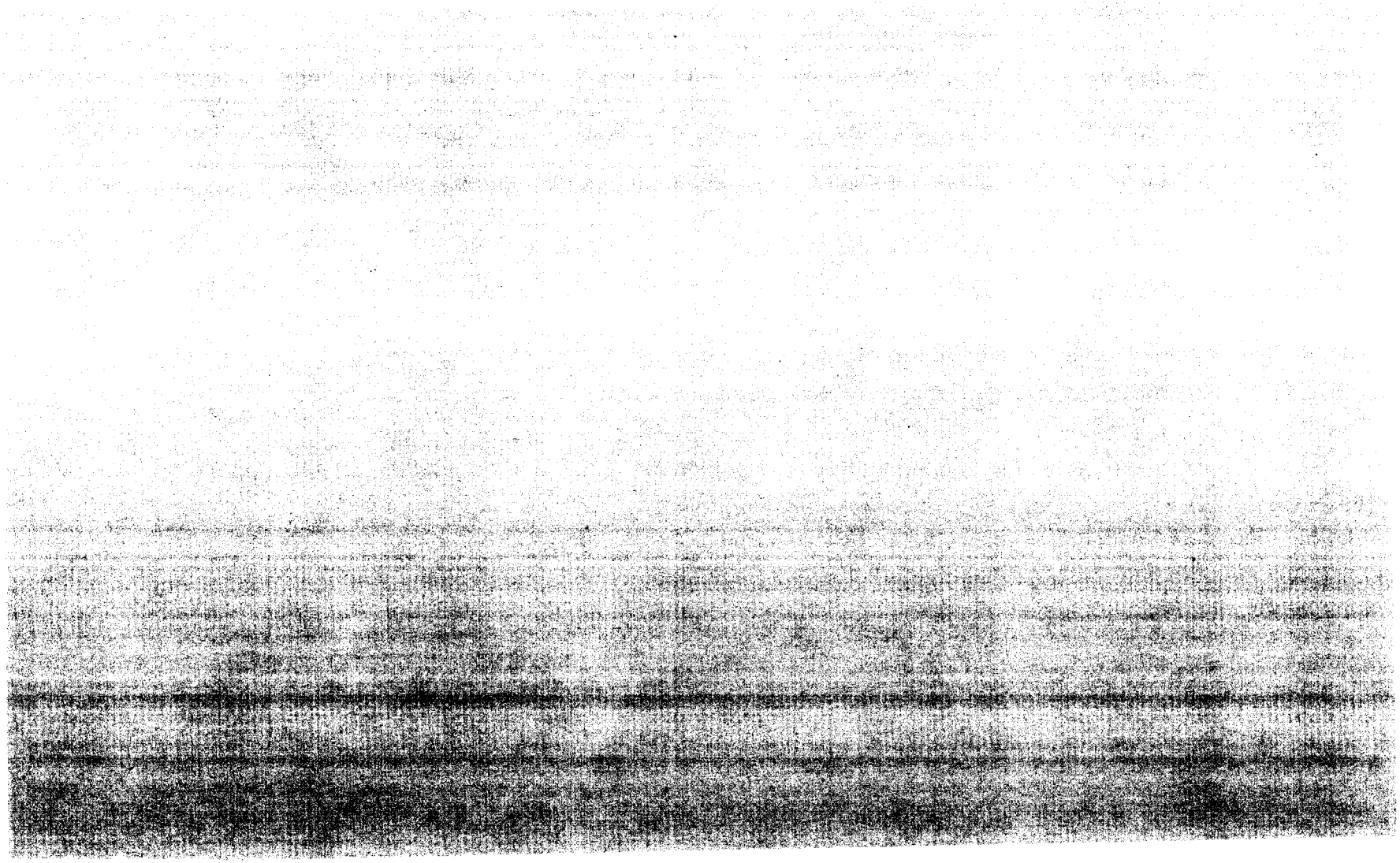
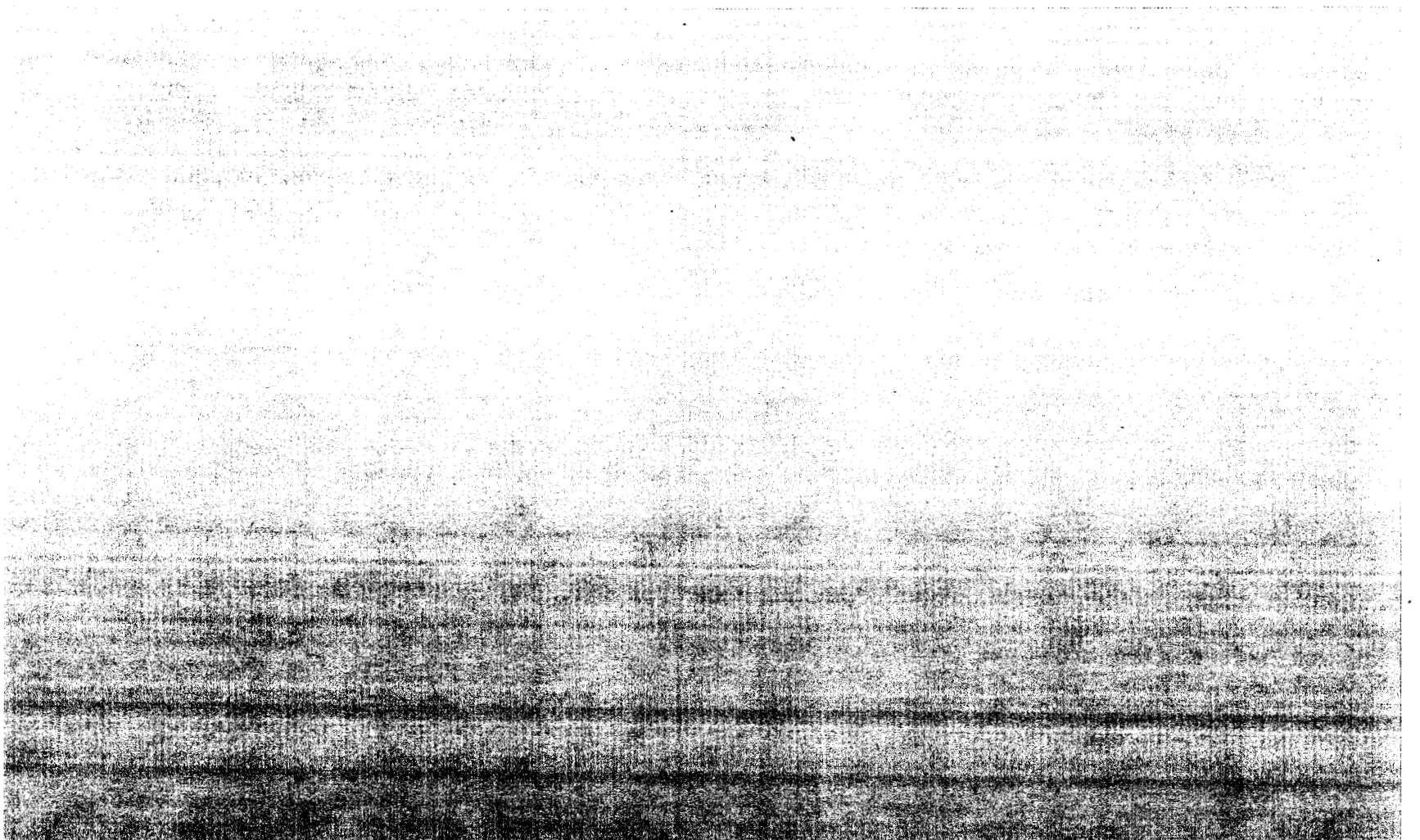
Other Issues

Skywave (<30 MHz)



New Information Arguing for Caution on HF BPL



What To Do

HF Issues and Options

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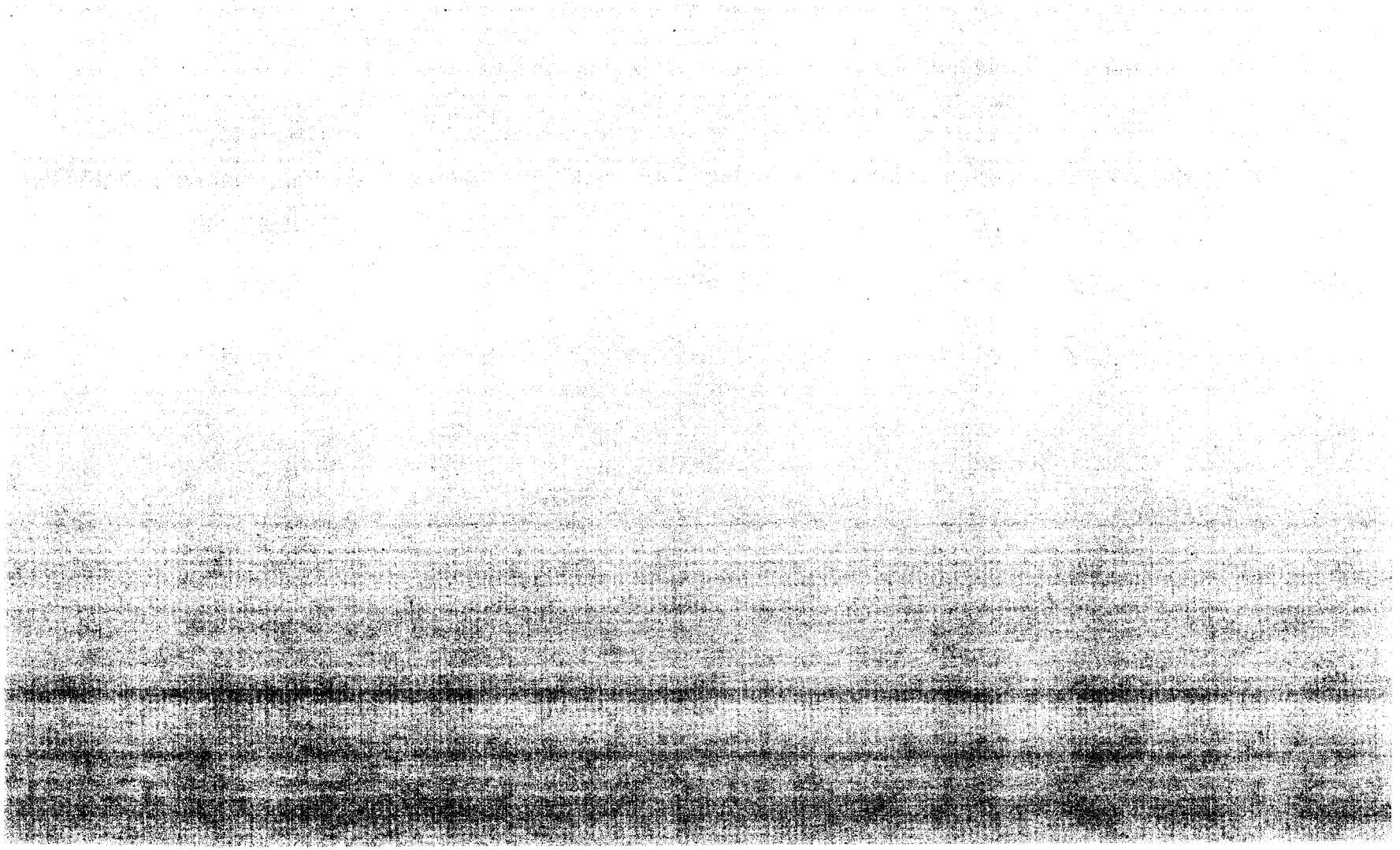

Low VHF Options

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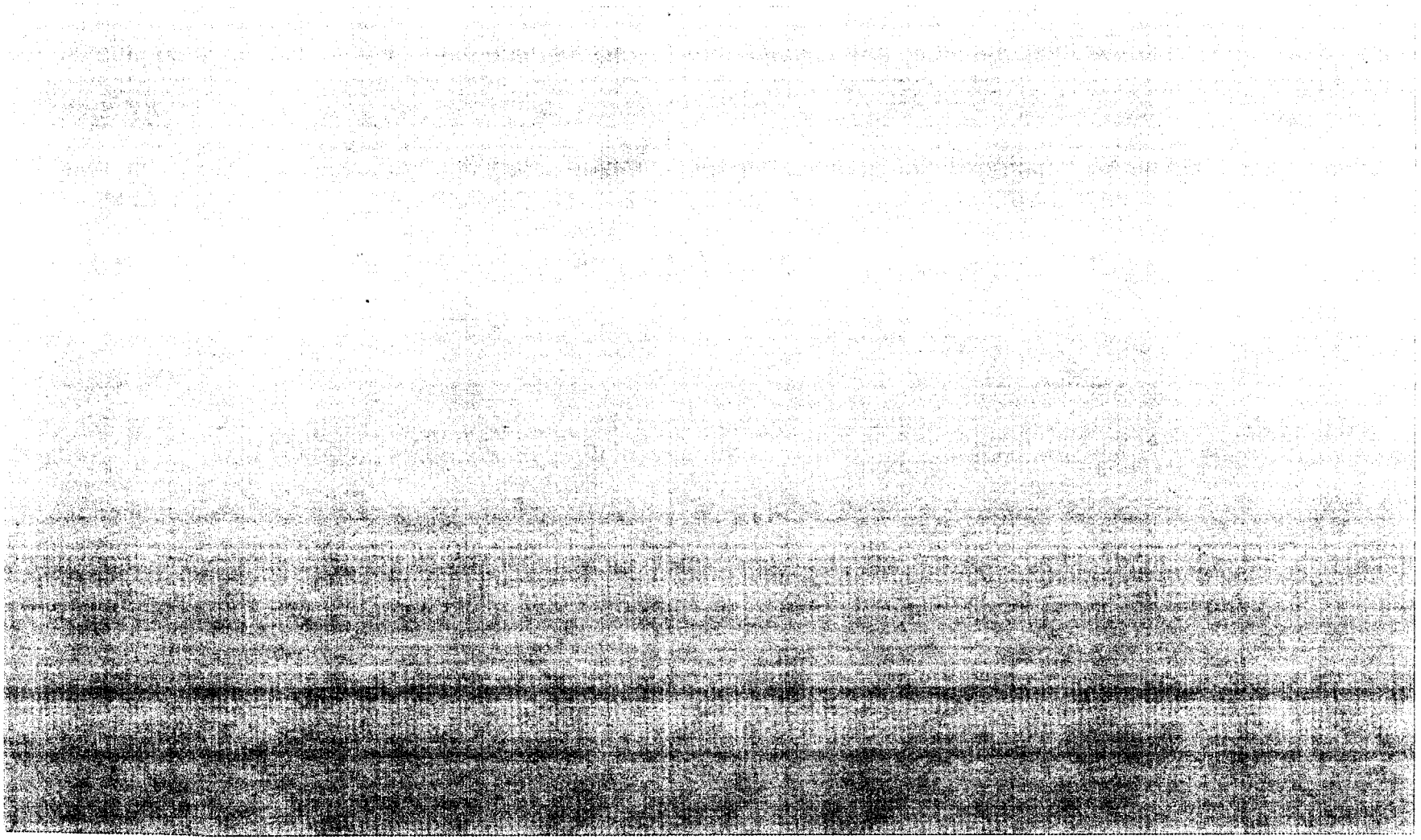
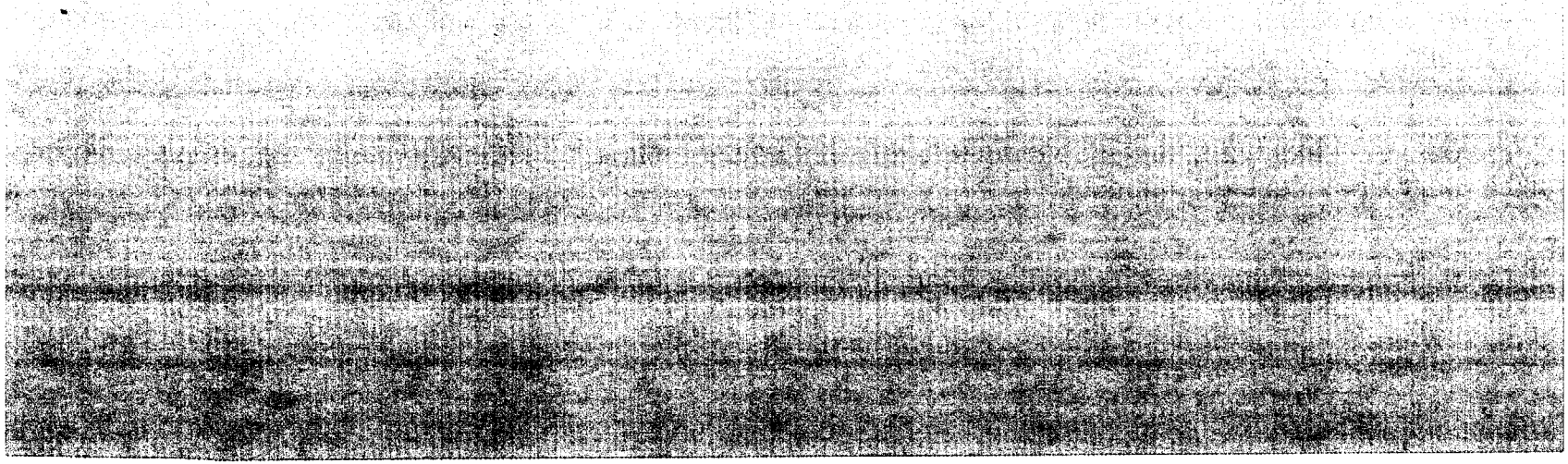


BPL Spectrum Tradeoffs and Proposal



BPL Emission Tests
Near Raleigh, North Carolina
June 28 – July 2, 2004

August 4, 2004

Steve Martin & Andy Leimer – FCC Laboratory

On site support: Joe Husnay & Luther Bolden – FCC Norfolk Resident Agent Office
Radio, GPS, S/W, & expertise: Dave Larrabe & Jim Higgins – FCC Monitoring Station

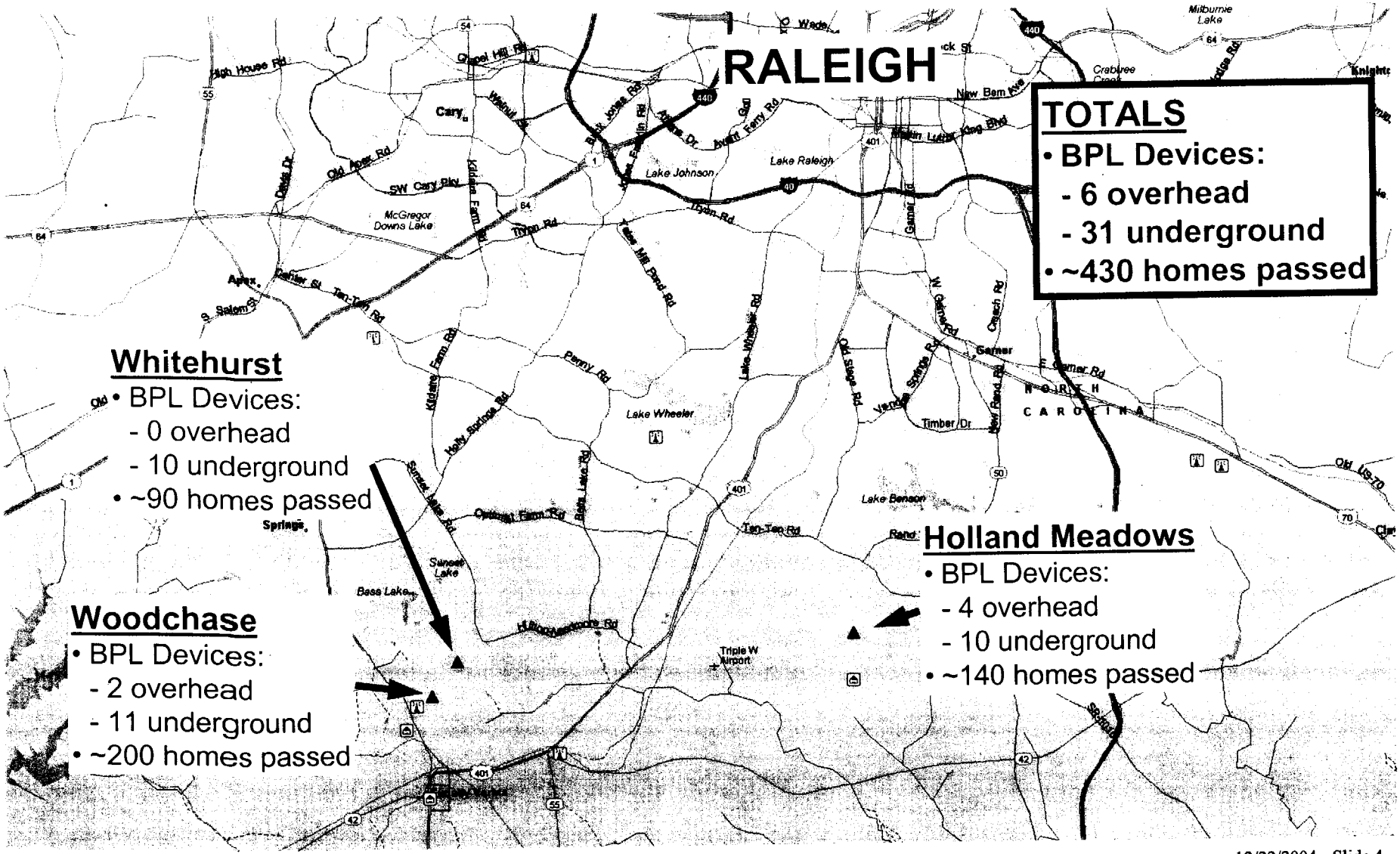
Outline

- Introduction
- Compliance with Emission Limits
- Emissions at Unprotected (Un-notched) Frequencies
- BPL Notch Effectiveness
- Fixed Amateur Sites

Introduction

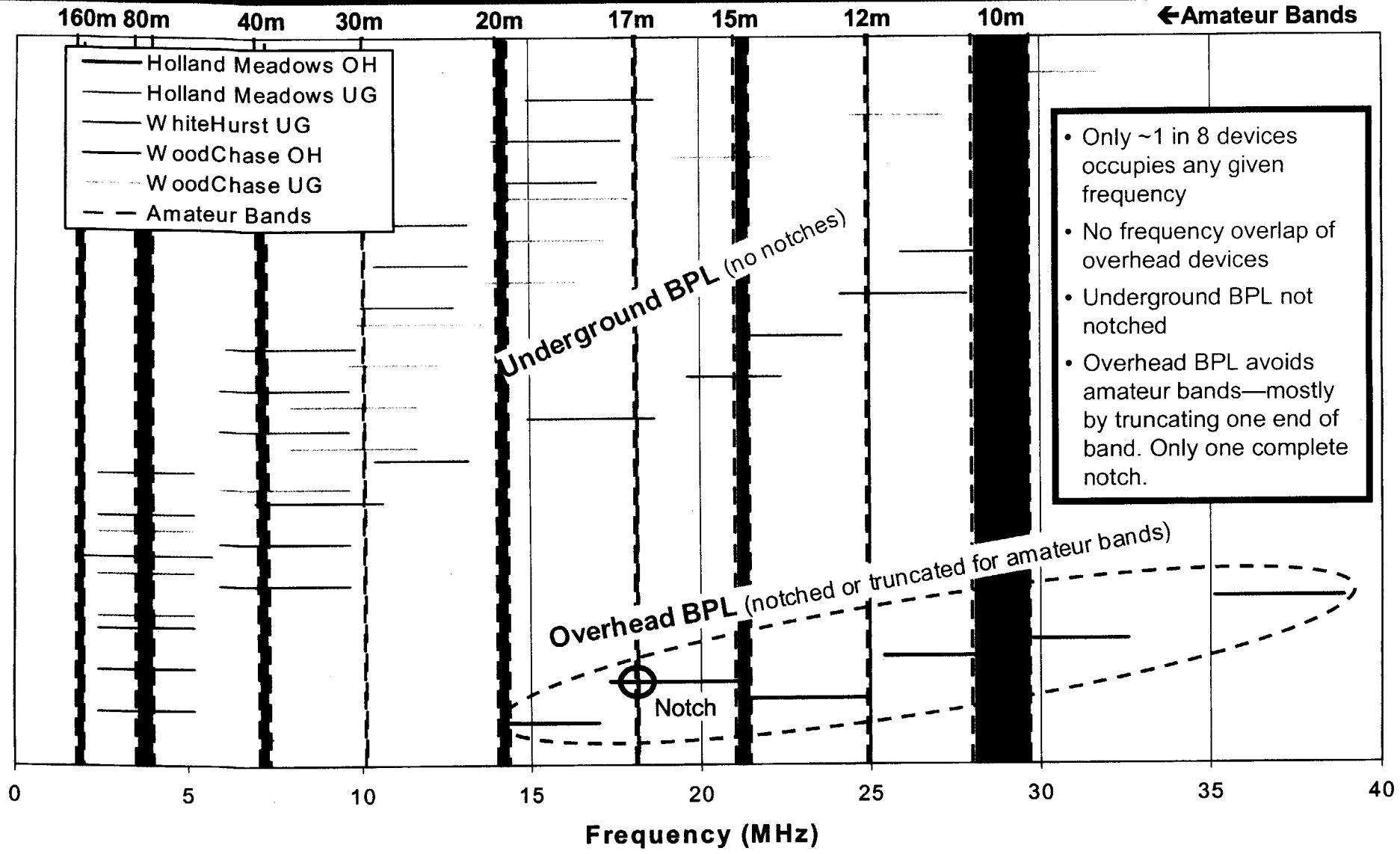
- **Tests of emissions from BPL systems deployed near Raleigh, NC were performed in response to complaints of interference to**
  - mobile amateur radio in the vicinity of three BPL installations
  - three fixed amateur installations at homes located 0.4 to 0.7 miles from overhead BPL installations

Amperion/Progress-Energy BPL Deployments Near Raleigh



BPL Device Frequencies in Raleigh Deployments

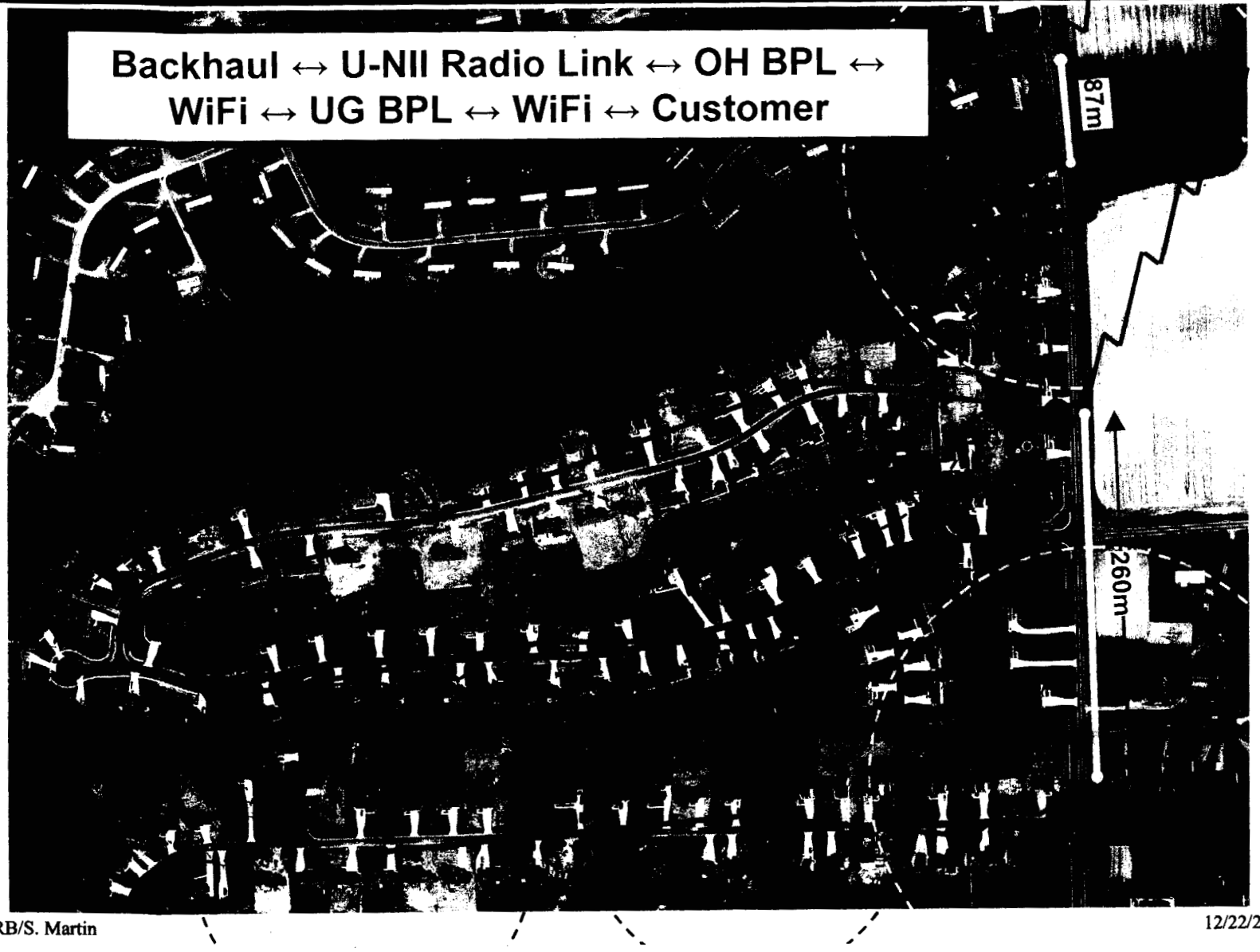
FCC Laboratory



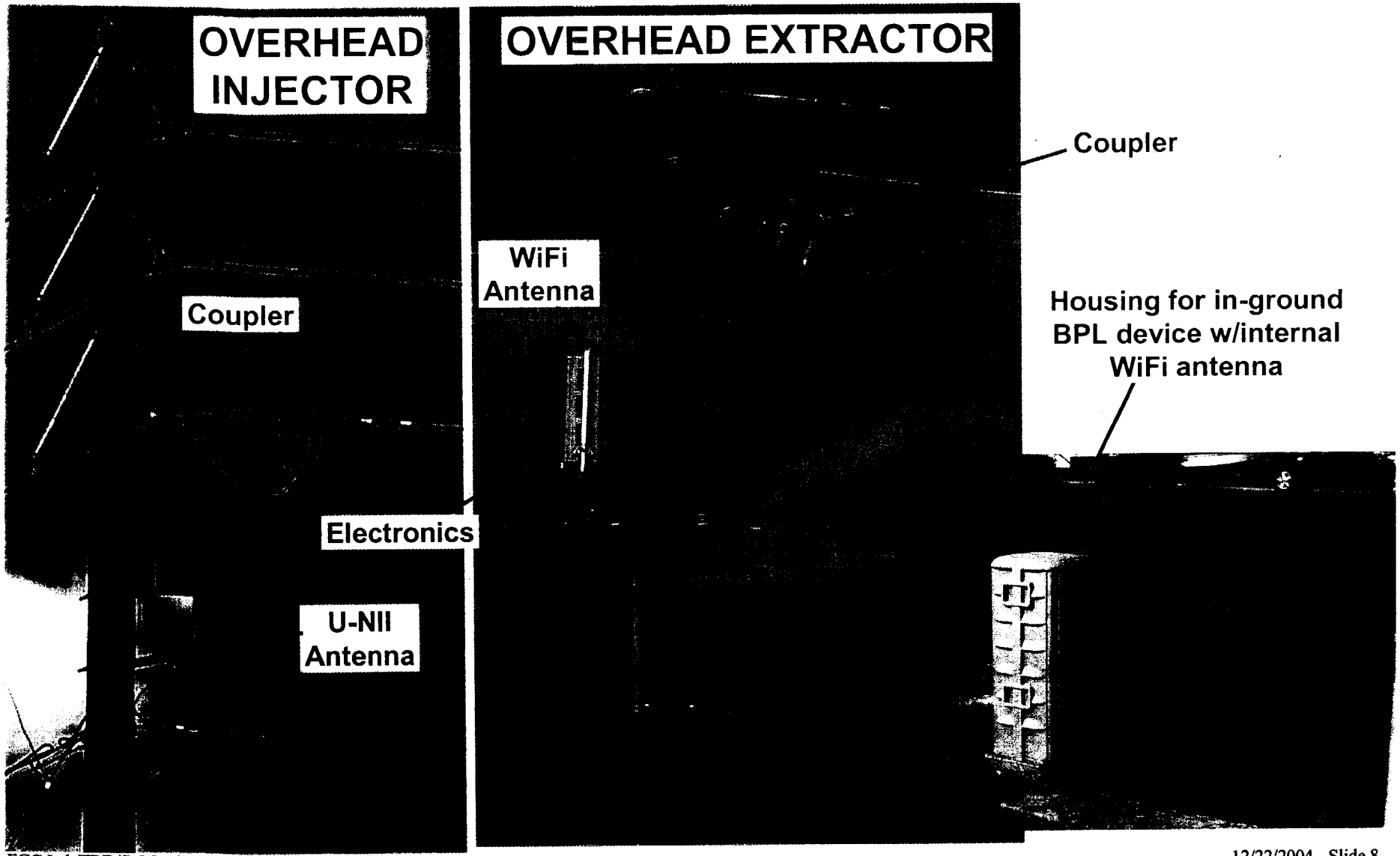
Amperion BPL System

- **Unusual Design Characteristics**
  - Frequency division multiplexing with relatively small bandwidth per device (2.75 or 3.75 MHz)
  - WiFi link to customers--No use of low voltage lines
    - Minimal emissions from building wiring → few above-ground emission sources where power lines are underground
- **Other Characteristics**
  - OFDM
  - Remote band selection & Remote "notching" by omitting OFDM carriers

Network Topology at Holland Meadows

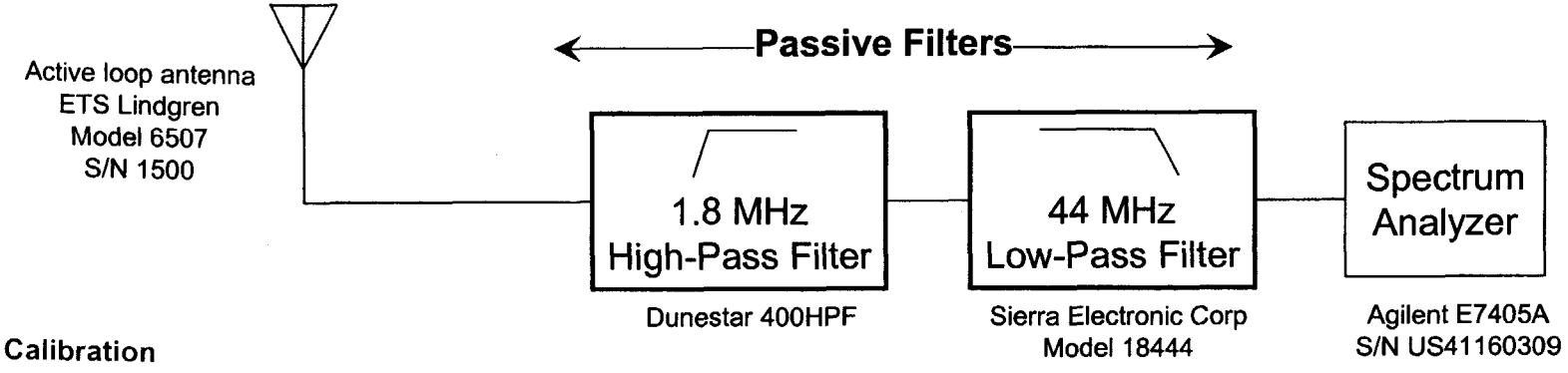


Amperion BPL Hardware



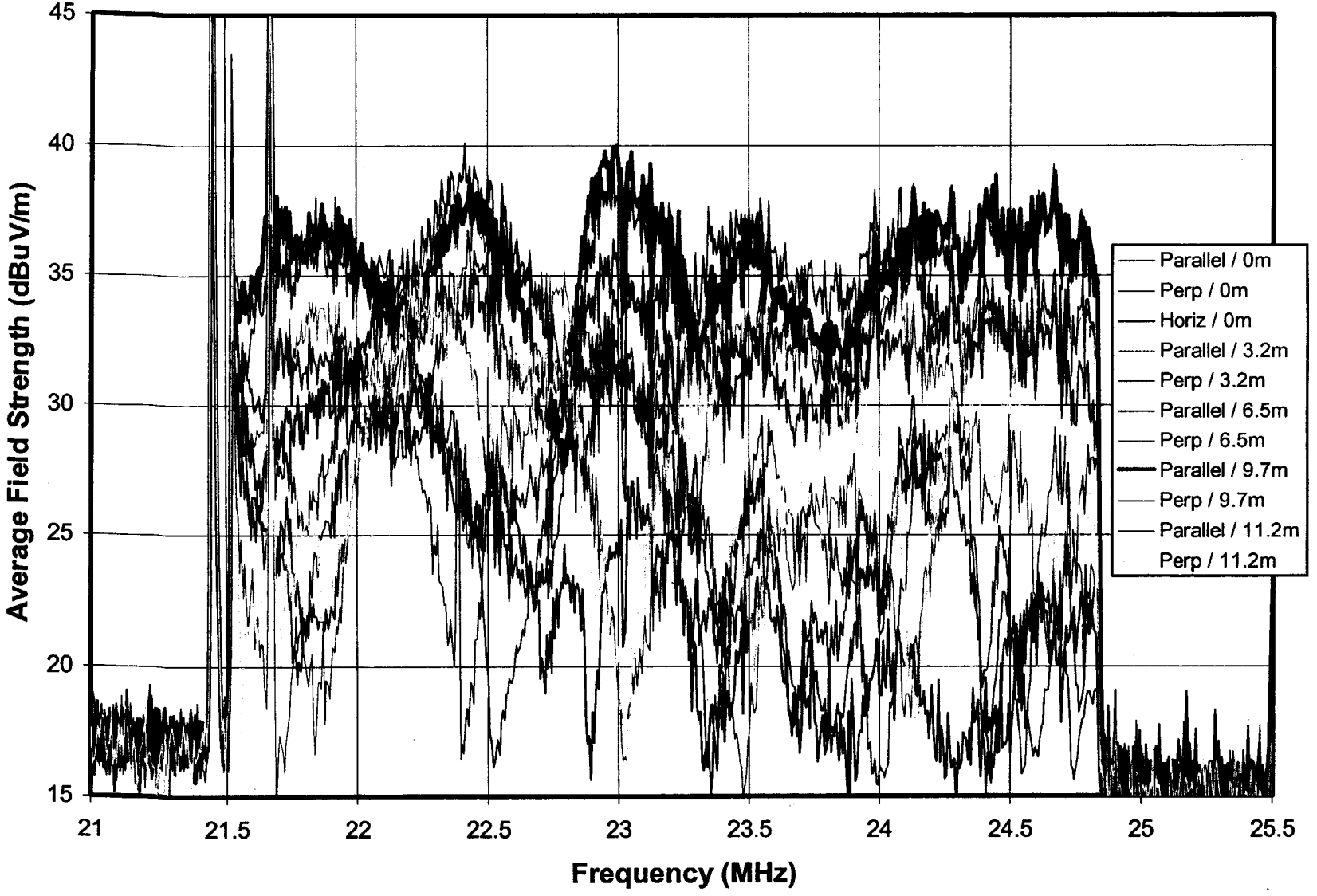
Compliance with Emission Limits

Test Description for Compliance Measurements

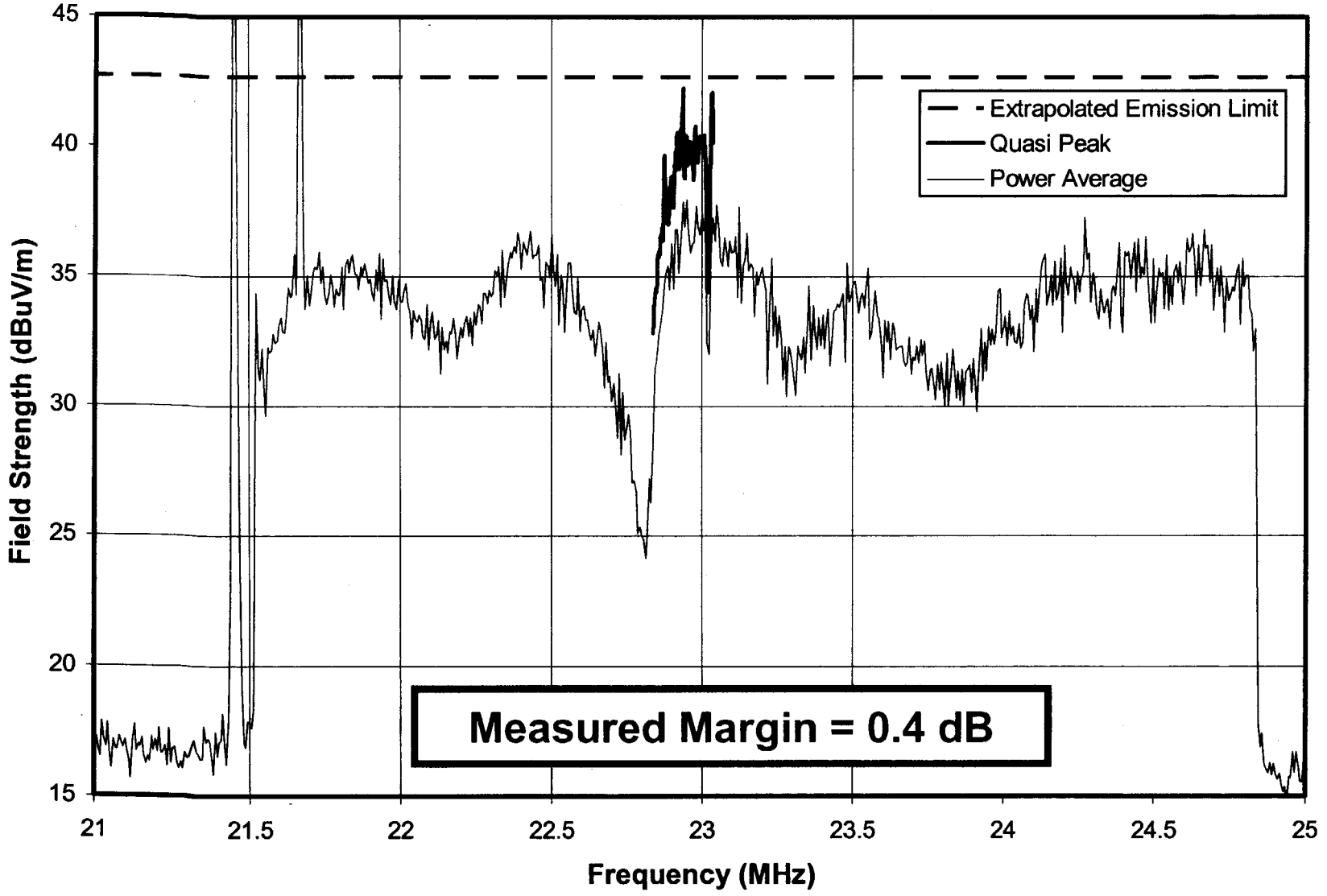


- **Calibration**
  - The combination of all cables & filters was calibrated, as a function of frequency, using the spectrum analyzer's tracking generator
- **Measurement locations**
  - Antenna height: 1 meter
  - Horizontal offset from the power line on which the BPL signals were injected: 10-meters (on the tobacco-field side of the power line rather than on the road side, for physical safety)
  - Distance down line from BPL coupler: 0, 0.25, 0.5, 0.75, & 1* wavelength (southwest of coupler at Woodchase; south of coupler at Holland Meadows)
    * - At Woodchase, the final measurement was 0.87 wavelength down line, due to a large mud puddle at one wavelength. Wavelengths were based on the BPL device center frequencies of 23.2 MHz at Woodchase and 19.2 MHz at Holland Meadows.
  - Antenna orientations
    - Two orientations used at both sites: (1) Plane of loop vertical & parallel to power line, (2) plane of loop vertical & perpendicular to power line
    - Third orientation (plane of loop horizontal) was tested at only one Woodchase location and yielded lower field strengths
- **Procedure**
  - Power average spectra were measured at each antenna location & orientation. Antenna was returned to the location exhibiting the maximum field strength and power average spectrum was repeated. CISPR quasi-peak measurement was performed in limited band around frequency of maximum emission
- **Distance extrapolation to 30-meter distance at which emission limit is specified**
  - 40 log of slant range from antenna to power line, based on optically-measured power line heights of 10.9 m at Whitehurst and 10.5 m at Holland Meadows
  - Extrapolation was applied to the emission limit rather than to the measured data, so that the plots indicate actual field strength observed at the antenna location

Compliance Tests on Overhead Injector on Slaughter Rd at Woodchase

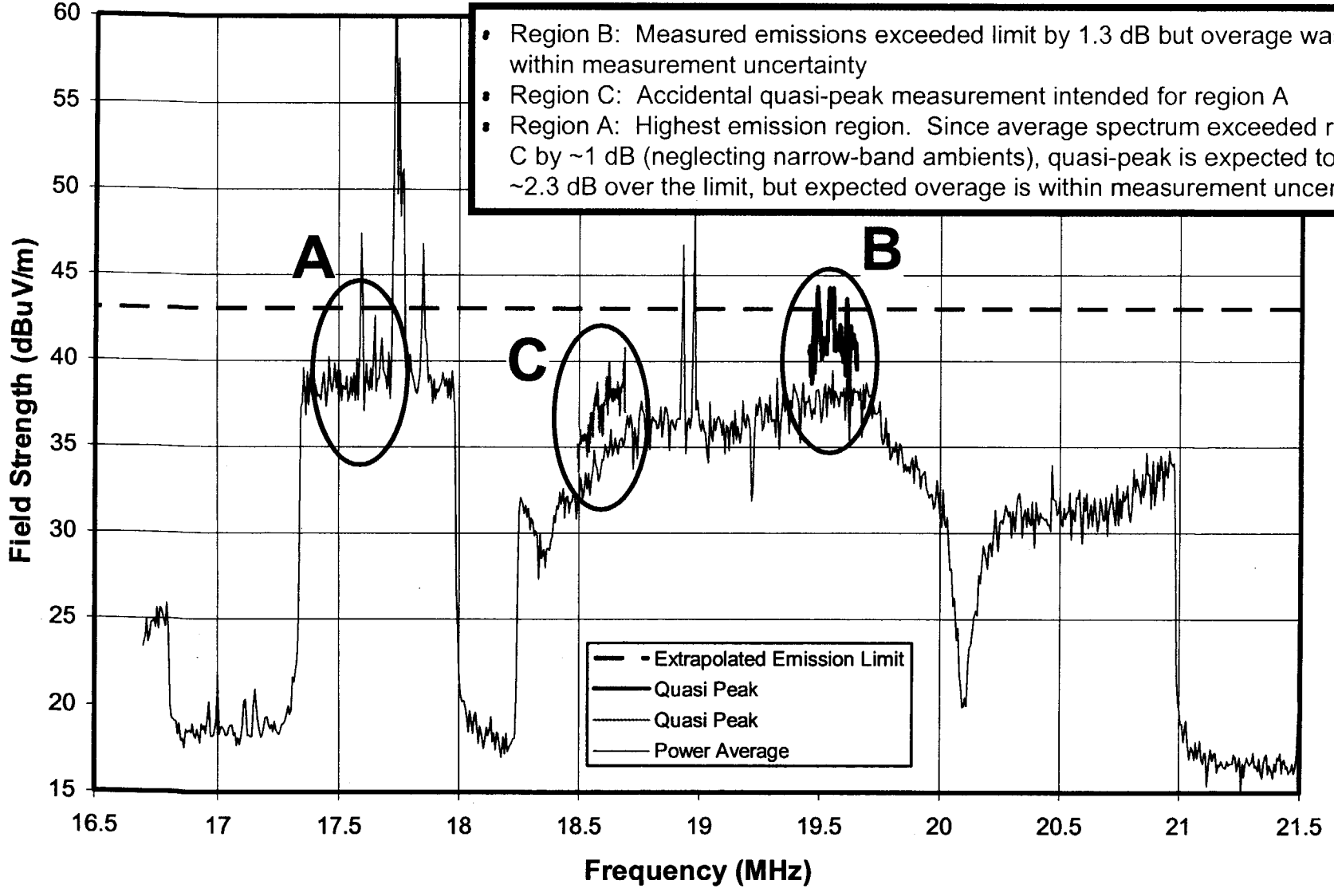


Compliance Tests on Overhead Injector on Slaughter Rd at Woodchase



Compliance Tests on 19.2-MHz Overhead Injector on Holland Church Rd

- Region B: Measured emissions exceeded limit by 1.3 dB but overage was within measurement uncertainty
- Region C: Accidental quasi-peak measurement intended for region A
- Region A: Highest emission region. Since average spectrum exceeded region C by ~1 dB (neglecting narrow-band ambients), quasi-peak is expected to be ~2.3 dB over the limit, but expected overage is within measurement uncertainty



Compliance with Emission Limits

- **Compliance results**
  - BPL devices on overhead power lines
    - Tested two overhead "injectors" (in-band emissions only) – Emission levels are at compliant (within measurement uncertainty) BPL devices on underground power lines
    - Not tested, but compliance expected based on radio tests, which indicated much lower emissions from underground wiring than overhead wiring

Interference Potential Outside of Notches

BPL on Underground Wiring

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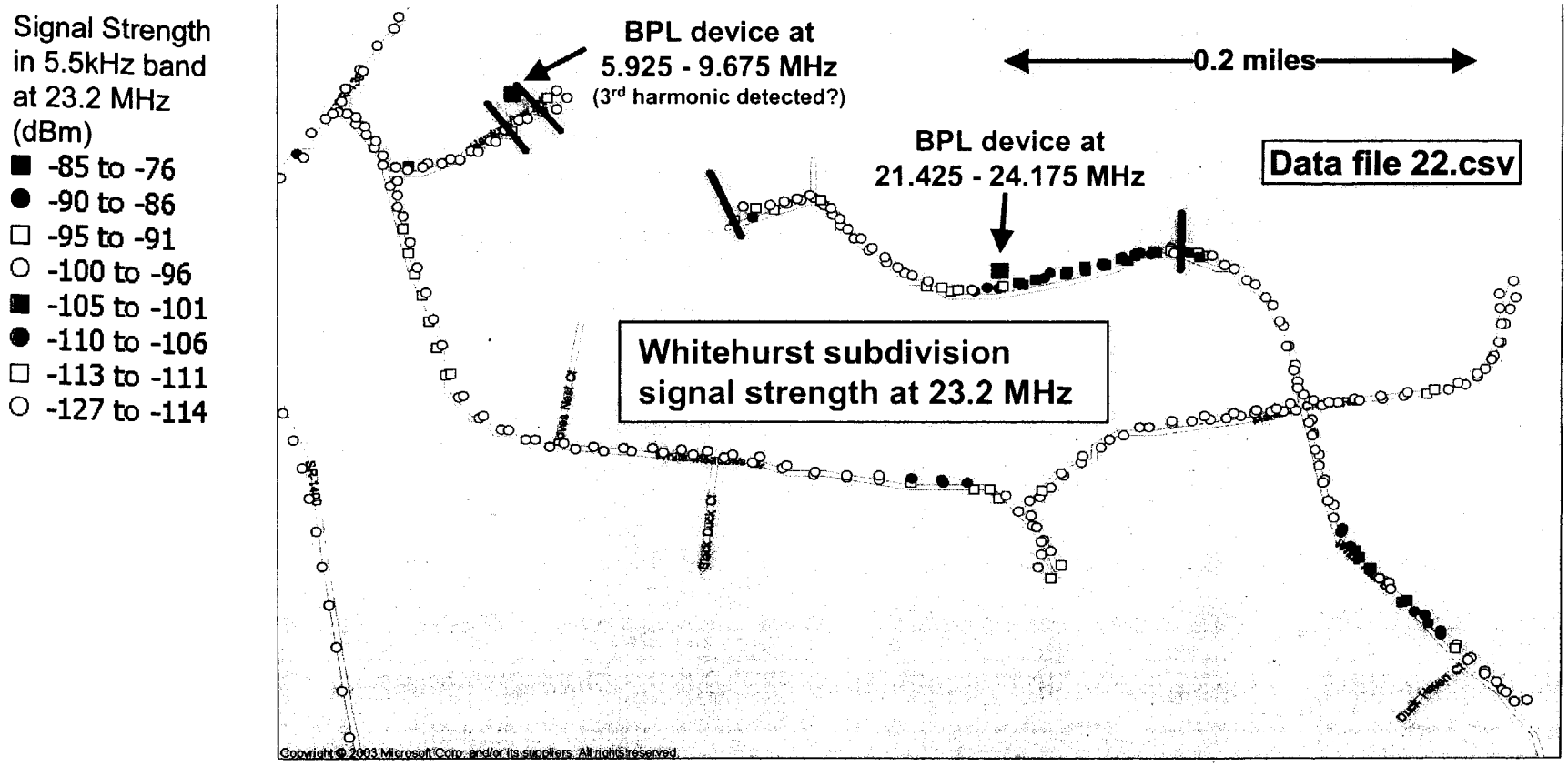
Geographic Extent of Emissions at One Frequency in Whitehurst



- **Underground BPL emissions are audible for short distances; e.g, at 23.2 MHz,**
  - Fundamental emissions were audible along 320 m (0.2 mi) of road around a BPL device
  - Emissions attributed to 3rd harmonic from another device were audible along 25 m of road

(Black lines mark edges of audibility)

Un-Notched Overhead BPL

(Geographic extent of emissions at 23.2 MHz from overhead injector)

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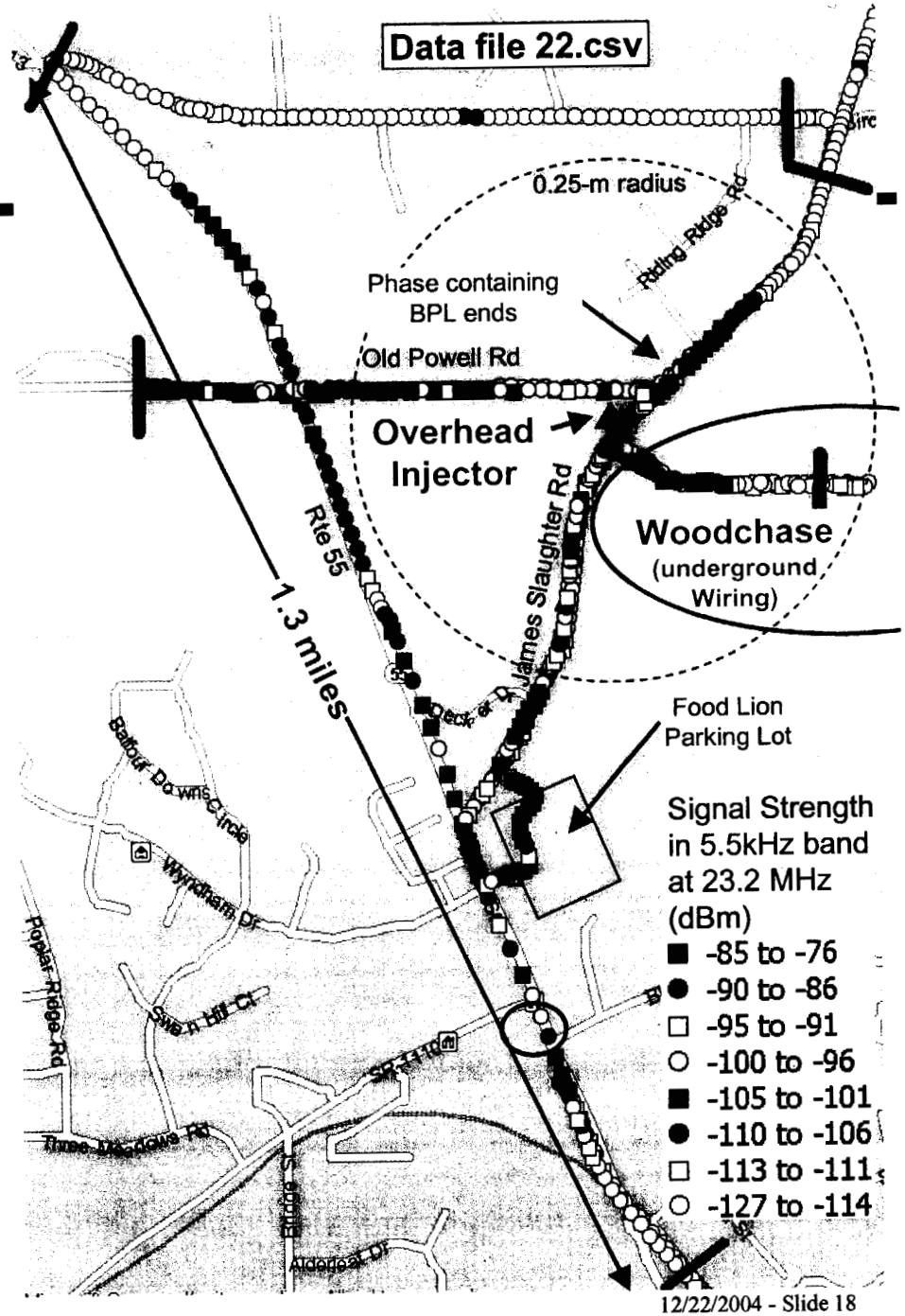
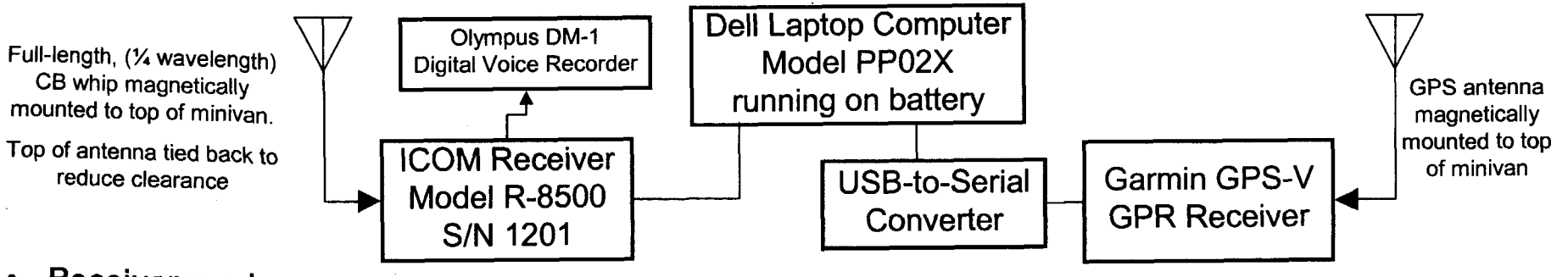
- **Effect of Single BPL Overhead Injector**
  - BPL audible (AM detector) between black lines
    - 3.5 miles of roadway outside of the subdivision served
    - 0.9 mi downline from coupler
    - 0.8 mi straight line distance from coupler
    - 0.19 mi (300m) from power line near coupler
  - Interference distance < audible distance
    - Distance depends on strength of desired signal, type of modulation, and margin required by listener or detector



Test Description for Audio/Video Collection of Mobile Radio Measurements



- **Receiver mode**
  - AM with 5.5 kHz bandwidth except where SSB is specified
- **Recording**
  - Audio was recorded on a Olympus DM-1 pocket-sized digital voice recorder by direct connection to the receiver audio output
  - Video was recorded through the windshield using a Canon Model ES75A Hi8 camcorder; audio from the receiver's speaker was recorded through the built-in microphone of the camcorder
- **Frequency selection**
  - For both tests, the receiver was tuned to an un-notched frequency within the injection band of the overhead BPL injector
  - For the audio-only test, the receiver was tuned to 23.185 MHz, a frequency having no obvious transmissions (except for BPL)
  - For the video test, the radio was tuned to 21.639 MHz, where a foreign language broadcast station was received
- **Signal strength and position logging and mapping for driving tests**
  - As described previously
  - The cable between the ICOM receiver and the laptop computer was inadvertently disconnected throughout the video listening test. Signal strength data plotted on the map is from a subsequent test run while tuned off of the shortwave station to a frequency of 21.718 MHz